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Research Report

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Research Project NM 13 01 99 Subtask 1

Report No. 5

THE RELATION BETWEEN SPEECH DISTURBANCE AND
PSYCHOPHYSIOLOGICAL CHANGES RESULTING FROM
DELAYED SPEECH FEEDBACK

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JOINT PROJECT

Central Institute for the Deaf, St. Louis, Missouri under
Contract Nonr-1151 (02) Project Designation No. (Nr 146-092)
and

U. S. Naval School of Aviation Medicine
The Bureau of Medicine and Surgery Project NM 13 01 99
Subtask 1 Report No. 5

THE RELATION BETWEEN SPEECH DISTURBANCE AND
PSYCHOPHYSIOLOGICAL CHANGES RESULTING
FROM DELAYED SPEECH FEEDBACK

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15 September 1957

SUMMARY PAGE

THE PROBLEM

This study was designed as an investigation of the hypothesis that severity of speech disturbance is inversely related to the magnitude of changes in psychophysiological responses during delayed speech feedback. Three measures of speech disturbance (speech rate, speech level, and speech fluency) and three measures of psychophysiological response (forearm tension, skin resistance, and heart rate) were employed.

Changes in response from a non-delayed speech situation to a delayed speech situation were determined, and correlations between magnitudes of speech changes and psychophysiological response changes were calculated.

FINDINGS

Changes in response from the non-delayed speech situation to the delayed speech situation were in the expected direction. There was an increase in forearm tension, heart rate, and speech level, and a decrease in skin resistance, speech rate, and speech fluency.

The only large correlations that were found were large negative correlations between 1) heart rate and speech rate, and 2) heart rate and speech level. These correlations provided partial support for the original hypothesis.

On the basis of the experimental results the original hypothesis was modified as follows: 1) If the subject maintains normal speech rate and speech level during delayed speech feedback, his compensatory effort is reflected by an increase in the activity of certain specific response systems. 2) The general increase in organismic activity (or stress reaction) that accompanies delayed speech feedback is not related to the severity of speech disturbance.

RECOMMENDATION

Further investigation of the relation between severity of speech disturbance and changes in specific psychophysiological response systems during delayed speech feedback is recommended.

INTRODUCTION

It was found in a previous report by one of us that certain psychophysiological changes are produced by delayed speech feedback* (1). Significant changes in heart rate, skin resistance, and blink rate were found to result from a condition of speech delay as compared with a condition of non-delayed speech. An unsystematic observation of speech disturbance as related to the psychophysiological changes suggested an inverse relationship between amount of speech disturbance and amount of psychophysiological change. If such were the case, psychophysiological changes could be the result of an attempt to compensate for the speech disturbance produced by delayed speech feedback. A more exact determination of the relationship between speech disturbance and psychophysiological changes in the delayed speech feedback situation could thus have important implications for the analysis of other types of speech disturbance, such as stuttering.

The present experiment was designed to test the hypothesis that there is a negative correlation between the severity of speech disturbance and the magnitude of change in psychophysiological responses accompanying delayed speech feedback. Three speech measures (rate of speech, level of speech, and fluency of speech) and three psychophysiological measures (heart rate, skin resistance, and forearm muscle tension) were employed. In each case the measure used was change in magnitude of response from a non-delayed to a delayed speech situation.

PROCEDURE

SUBJECTS

Subjects were 20 naval aviation cadets.

EXPERIMENTAL DESIGN

Two experimental conditions were employed: reading with non-delayed speech feedback and reading with delayed speech feedback. Each subject was given four one-minute trials, during which he read aloud one of four simple printed passages. During the first thirty seconds of each trial the speech was not delayed, and during the second thirty seconds the side-tone was delayed.

*A longer-than-normal delay between the emission of speech and delivery of the speech via an airborne channel to the speaker's ears is called "delayed speech feedback." Considerable disturbance of speech occurs with delays of 0.06 to 0.35 second.

EQUIPMENT

The printed reading material and the equipment and recording procedures for the psychophysiological measures were the same as those used in the previous experiment (1), except that in this experiment only heart rate, skin resistance, and forearm muscle tension were recorded.

The speech-delay system was somewhat different from that used previously. The subject wore a headset (HS-33) containing earphones (PDR-8) in NAF-48940-1 ear-phone cushions. A condenser microphone (Altec 21-D) was attached to the headset and positioned along the cheek, out of the breath blast. Speech was fed through the microphone to a tape recorder (Ampex 600-N) either directly to the earphones (non-delay) or from the "record" head to the "playback" head and then back to the earphones (delay). For the latter condition there was a side-tone delay of approximately 0.15 second. This system made possible a continuous recording of the subject's speech.

METHOD

After the earphones and recording equipment had been attached, the subject was required to answer several questions. This served to relax him and to allow a side-tone level adjustment sufficient to insure masking of bone-conducted speech. Reading material was then placed before the subject, and he was instructed to read aloud until told to stop. When he had read for thirty seconds, the output of the tape recorder was switched from record to playback. For the subject this meant a change from direct speech reception to delayed speech reception. All of the subject's speech was recorded. Four trials were given in this way, with an interval of thirty to forty-five seconds between trials.

MEASUREMENT OF RECORDS

For each response variable the magnitude of response during both delay and non-delay was determined for each trial, and the final measure was the mean change in magnitude from the non-delay condition to the delay condition. This provided a control for individual differences in response during "normal" speech.

Change in forearm muscle potential was measured in microvolts, with the last ten-second integration during non-delay being subtracted from the largest of the three ten-second integrations during delay. Heart rate change was measured by subtracting the rate during the last ten seconds of non-delay from the highest rate occurring among three ten-second divisions of the delay period. Change in skin resistance was measured by taking a ratio of the maximum decrease in resistance (in ohms) during the delay period to the resistance level at the end of the non-delay period (1).

A complete discussion of the measurement of changes in speech rate, speech level, and speech fluency is given in another report (2). Briefly, change in speech rate was measured by subtracting word output during non-delay from word output during delay. Speech level change was measured by subtracting the average peak level (in decibels) during non-delay from the average peak level during delay. Change in speech fluency was measured by subtracting fluency rating values (as rated on a seven-point scale) during non-delay from fluency rating values during delay.

Four measures of change (one per trial) were thus obtained for each response variable. A mean of the four measures was used in the calculation of correlations in all cases except that of heart rate at the beginning of Trial 1; therefore Trials 2, 3, and 4 only were used for the calculation of average change in heart rate.

RESULTS

The results of one subject for the measures of forearm tension and skin resistance each were discarded because of equipment malfunction. Table I shows mean changes in magnitude of response from the non-delay condition to the delay condition. All changes were in the expected direction. From non-delayed to delayed speech there was an increase in forearm tension, an increase in heart rate, a decrease in skin resistance, a decrease in speech rate, an increase in speech level, and a decrease in speech fluency. For the calculation of correlations all of these changes were treated as positive quantities in order to avoid confusion in the interpretation of results.

Speech disturbance changes were correlated with psychophysiological response changes by the rank-difference method, with the results shown in Table II. None of the correlations was significantly different from zero (a correlation of $\pm .47$ is required for statistical significance at the 5 per cent level of confidence with twenty subjects). It should be noted, however, that there was a large negative correlation between heart rate and speech rate, and between heart rate and speech level. All of the other correlations were relatively small.

TABLE I

Change in Response from Non-Delayed to Delayed Speech*

Response	N	Mean Change	Unit of Measure
Forearm Tension	19	1.4	10-sec integration (microvolts)
Heart Rate	20	0.7	Heart rate per 10 sec
Skin Resistance	19	-0.6	Maximum decrease/initial level (ohms)
Speech Rate	20	-22.0	Word Output per 20 sec
Speech Level	20	4.3	Average peak level (decibels)
Speech Fluency	20	-2.4	Seven-point fluency rating

*The mean of the changes on trials 1 through 4 is given, except for heart rate, where the mean of changes on trials 2 through 4 is given.

TABLE II

Rank-Difference Correlations of Speech Disturbance Changes with Psychophysiological Response Changes

Psychophysiological Response	Rate	Speech Disturbance	
		Level	Fluency
Forearm Tension	0.01	0.18	-0.08
Heart Rate*	-0.38	-0.35	-0.08
Skin Resistance	0.16	0.09	0.18

*The results of Trials 2, 3, and 4 only were used for the calculation of heart rate changes. These were correlated with mean changes on Trials 2, 3, and 4 for each speech measure.

DISCUSSION

It was hypothesized that there is an inverse relationship between the severity of speech disturbance and the magnitude of psychophysiological responses accompanying delayed speech feedback. This relationship was not found when the measures of skin resistance and forearm tension were correlated with the speech disturbance measures. Changes in these responses are apparently part of a reaction to the general stress of the delayed speech feedback situation.

The large negative correlations between heart rate and two of the speech measures cannot, however, be disregarded. Even though the correlations were non-significant, there is a definite possibility that maintenance of normal speech rate and level during speech delay entails an increase in heart rate. Taking into consideration the lack of negative correlations involving skin resistance and forearm tension, it could be argued that compensation for speech disturbance results in changes in specific response systems rather than a general increase in organismic tension.

This modified hypothesis must, of course, be tested experimentally. It is felt that a partial replication of the present investigation would help to clarify the situation, with heart rate changes being correlated with speech rate and speech level changes. In carrying out such an experiment it is recommended that 1) more subjects be tested, and 2) more precise measures of heart rate change be obtained*. Finally, a further specification of the compensation process might be accomplished by relating speech disturbance to response systems that seem to be closely associated with speech behavior, e.g., the respiratory system and the speech musculature.

*At the polygraph paper speed of 6 mm/sec used in this experiment, heart rate could be measured to an accuracy of only 0.5 cycles. If a paper speed of 6 mm/sec were used, heart rate could be measured to an accuracy of at least 0.1 cycles.

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